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DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

JEL 31212

U.S. APPLICATION NO. (IF KNOWN SEE 37 CFR

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INTERNATIONAL APPLICATION NO.
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TITLE OF INVENTION

RADIO COMMUNICATION APPARATUS AND TRANSMISSION ANTENNA CHANGING METHOD

APPLICANT(S) FOR DO/EO/US

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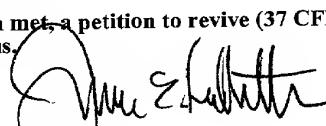
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. This is a **SECOND or SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. has been transmitted by the International Bureau.
 - c. is not required, as the application was filed in the United States Receiving Office (RO/US).
6. A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. A copy of the International Search Report (PCT/ISA/210).
8. Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. have been transmitted by the International Bureau.
 - c. have not been made; however, the time limit for making such amendments has NOT expired.
 - d. have not been made and will not be made.
9. A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. A **FIRST** preliminary amendment.
16. A **SECOND or SUBSEQUENT** preliminary amendment.
17. A substitute specification.
18. A change of power of attorney and/or address letter.
19. Certificate of Mailing by Express Mail
20. Other items or information:

**PCT/RO/101
Claim for Priority with PCT/IB/304
PCT/IB/308**

| U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/600329 | INTERNATIONAL APPLICATION NO. PCT/JP99/06378 | ATTORNEY'S DOCKET NUMBER JEL 31212 | | | | | | | | | | | | | | | | | | | | |
|---|--|--|---------------------------|--------------|---------|--------------|-----------|---|-----------|--------------------|---------|---|-----------|--|--|--|---|--|--|--|---------------|--|
| 21. The following fees are submitted: | | CALCULATIONS PTO USE ONLY | | | | | | | | | | | | | | | | | | | | |
| BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) : | | | | | | | | | | | | | | | | | | | | | | |
| <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) | | \$970.00 \$840.00 \$690.00 \$670.00 \$96.00 \$840.00 | | | | | | | | | | | | | | | | | | | | |
| ENTER APPROPRIATE BASIC FEE AMOUNT = | | \$840.00 | | | | | | | | | | | | | | | | | | | | |
| Surchage of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)). | | <input type="checkbox"/> 20 <input type="checkbox"/> 30 \$0.00 | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">CLAIMS</th> <th style="width: 25%;">NUMBER FILED</th> <th style="width: 25%;">NUMBER EXTRA</th> <th style="width: 25%;">RATE</th> </tr> </thead> <tbody> <tr> <td>Total claims</td> <td>21 - 20 =</td> <td>1</td> <td>x \$18.00</td> </tr> <tr> <td>Independent claims</td> <td>8 - 3 =</td> <td>5</td> <td>x \$78.00</td> </tr> <tr> <td colspan="3"></td> <td style="text-align: center;">□</td> </tr> <tr> <td colspan="3"></td> <td style="text-align: right;">\$0.00</td> </tr> </tbody> </table> | | CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | Total claims | 21 - 20 = | 1 | x \$18.00 | Independent claims | 8 - 3 = | 5 | x \$78.00 | | | | □ | | | | \$0.00 | |
| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | | | | | | | | | | | | | | | | | | |
| Total claims | 21 - 20 = | 1 | x \$18.00 | | | | | | | | | | | | | | | | | | | |
| Independent claims | 8 - 3 = | 5 | x \$78.00 | | | | | | | | | | | | | | | | | | | |
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| | | | \$0.00 | | | | | | | | | | | | | | | | | | | |
| Multiple Dependent Claims (check if applicable). | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL OF ABOVE CALCULATIONS = | | \$1,248.00 | | | | | | | | | | | | | | | | | | | | |
| Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). | | <input type="checkbox"/> \$0.00 | | | | | | | | | | | | | | | | | | | | |
| SUBTOTAL = | | \$1,248.00 | | | | | | | | | | | | | | | | | | | | |
| Processing fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)). | | <input type="checkbox"/> 20 <input type="checkbox"/> 30 + \$0.00 | | | | | | | | | | | | | | | | | | | | |
| TOTAL NATIONAL FEE = | | \$1,248.00 | | | | | | | | | | | | | | | | | | | | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). | | <input checked="" type="checkbox"/> \$40.00 | | | | | | | | | | | | | | | | | | | | |
| TOTAL FEES ENCLOSED = | | \$1,288.00 | | | | | | | | | | | | | | | | | | | | |
| | | <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Amount to be: refunded</td> <td style="width: 50%;">\$</td> </tr> <tr> <td>charged</td> <td>\$</td> </tr> </table> | Amount to be: refunded | \$ | charged | \$ | | | | | | | | | | | | | | | | |
| Amount to be: refunded | \$ | | | | | | | | | | | | | | | | | | | | | |
| charged | \$ | | | | | | | | | | | | | | | | | | | | | |
| <p><input checked="" type="checkbox"/> A check in the amount of \$1,288.00 to cover the above fees is enclosed.</p> <p><input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.</p> <p><input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 19-4375 A duplicate copy of this sheet is enclosed.</p> | | | | | | | | | | | | | | | | | | | | | | |
| <p>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</p> <p>SEND ALL CORRESPONDENCE TO:</p> <p>James E. Ledbetter Stevens, Davis, Miller & Mosher, LLP 1615 L Street N.W., Suite 850 P.O. Box 34387 Washington, D.C. 20043-4387 Telephone: 202/408-5100 Facsimile: 202/408-5200</p> | | | | | | | | | | | | | | | | | | | | | | |
|  SIGNATURE <hr/> James E. Ledbetter <hr/> NAME <hr/> 28,732 <hr/> REGISTRATION NUMBER <hr/> July 14, 2000 <hr/> DATE | | | | | | | | | | | | | | | | | | | | | | |

534 Rec'd PCT/PTO 14 JUL 2000

DESCRIPTION

RADIO COMMUNICATION APPARATUS AND TRANSMISSION
ANTENNA CHANGING METHOD

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Technical Field

The present invention relates to a radio communication apparatus in a radio communication system that performs radio transmission using selective diversity, and relates to a transmission antenna changing method.

Background Art

In recent years, there has been adopted space diversity in which a plurality of antenna branches (hereinafter simply referred to as "antenna") is provided in a base station apparatus to reserve a plurality of paths. As one of space diversity, there is selective diversity that selects an optimal antenna in accordance with a propagation state. A method, which uses selective diversity at the transmission side, is hereinafter referred to as transmission selective diversity. Transmission selective diversity in a radio communication apparatus of TDD (Time Division Duplex) system has been already disclosed in the document "Transmission Characteristics of Next Generation W-CDMA/TDD system (Report, SSE97-41, RCS97-36

(1997-06), the Institute of Electronics, Information and Communication Engineers)" and the like.

This method is one in which correlation values of the respective branches of a reverse link are averaged over one previous slot (0.625 ms) to obtain reception power for a communication channel, and an antenna having higher reception power is selected to carry out transmission for slot (0.625ms) in a forward link.

Thus, in the case of the radio communication apparatus of TDD system, which uses the same frequency in both reverse and forward links, a transmission antenna can be selected based on reception power of the reverse link

While, in the case of the radio communication apparatus of FDD (Frequency Division Duplex) system, which uses a different frequency in each of the reverse and forward links, since the transmission antenna cannot be selected based on reception power of the reverse link, and the transmission antenna of a base station is selected based on reception power of one previous slot control signal in a terminal apparatus.

Regarding transmission selective diversity in the conventional radio communication apparatus of FDD system, the following will exemplify the case of CDMA system.

First, the base station apparatus transmits a control signal of spreading code A from antenna A, and a control signal of spreading code B from antenna B. Then, a terminal apparatus measures reception power of spreading code A and that of spreading code B, respectively, and reports spreading code having higher reception power, that is, antenna number to the base station apparatus. The base station apparatus selects an antenna for transmitting data to the terminal apparatus based on the report from the terminal apparatus.

Here, in a communication system such as CDMA, which has high resolution with respect to a delay wave, there is a case in which RAKE combining, which combines received signals each having a different arrival time, is carried out to improve performance of reception. When the number of reception paths is large, the reception characteristic on the receiving side is little improved by the characteristic of RAKE combining even if the transmission antenna is changed on the transmitting side. Moreover, if the transmission antenna is changed, reception power of an interference signal is largely changed in the other terminal apparatus, so that reception quality becomes worse. Therefore, in consideration of the entirety of system, execution of changing the transmission antenna is desirably constrained to a minimum.

However, the transmission selective diversity of the conventional radio communication apparatus of FDD system has a problem in which the change of antenna is executed even when the reception characteristic of the receiving side is little improved, that is, the change of antenna is unnecessary.

Disclosure of Invention

A first object of the present invention is to provide a radio communication apparatus of FDD system, which executes an operation for changing a transmission antenna only when reception quality is improved by changing the transmission antenna, and to provide a transmission antenna changing method.

The above object can be achieved by measuring the number of paths of a link from a delay profile of received signal and determining whether or not the operation for changing the antenna is executed based on the measured number of paths.

Brief Description of Drawings

FIG. 1 is a block diagram showing a configuration of a base station apparatus according to Embodiment 1 of the present invention;

FIG. 2 is a block diagram showing a configuration of a terminal apparatus according to Embodiment 1;

FIG. 3 is a view explaining a delay profile according to Embodiment 1;

FIG. 4 is a flowchart showing processing of a determining circuit according to Embodiment 1;

5 FIG. 5 is a block diagram showing a configuration of a base station apparatus according to Embodiment 2 of the present invention;

FIG. 6 is a block diagram showing a configuration of a terminal apparatus according to
10 Embodiment 2;

FIG. 7 is a block diagram showing a configuration of a base station apparatus according to Embodiment 3 of the present invention;

FIG. 8 is a block diagram showing a configuration of a terminal apparatus according to
15 Embodiment 3;

FIG. 9 is a block diagram showing a configuration of a terminal apparatus according to Embodiment 4; and

20 FIG. 10 is a flowchart showing processing of a determining circuit according to Embodiment 4.

Best Mode for Carrying out the Invention

25 Embodiments of the present invention will be specifically explained with reference to the drawings attached thereto.

(Embodiment 1)

Embodiment 1 focuses on the point in which

diversity effect, which is caused by a change of antenna, is small since path diversity effect, which is caused by RAKE combing, is obtained when the number of reception paths is large. More specifically, Embodiment 1 is a specific form wherein a terminal apparatus measures the number of reception paths from a received signal to determine whether or not a change of antenna is needed based on the measured number of paths, and transmits information, which shows a determination result, to a base station apparatus, and the base station apparatus selects whether or not the change of antenna is executed based on the determination result received the terminal apparatus.

FIG. 1 is a block diagram showing the configuration of the base station apparatus according to Embodiment 1 of the present invention.

In the base station apparatus of FIG. 1, an antenna duplexer 103 is used such that the same antenna is employed in both transmission and reception. The antenna duplexer 103 outputs a signal radio received by an antenna 101 to a reception RF section 105, and outputs a transmission signal output from a transmission RF section 121 to the antenna 101. Similarly, an antenna duplexer 104 outputs a signal radio received by an antenna 102 to a reception RF section 106, and outputs a transmission signal output from a transmission RF

section 122 to the antenna 102.

The reception RF sections 105 and 106 amplify received signals input from the antenna duplexers 103 and 104, frequency convert the amplified signals 5 to intermediate or baseband frequencies, and output the frequency-converted signals to matched filters 107 and 108, respectively. The matched filters 107 and 108 perform despreading by multiplying the output signals of reception RF sections 105 and 106 10 by the same spreading code D multiplied by the terminal apparatus, respectively. Then, the matched filters 107 and 108 send the resultant to a delay profile measuring circuits 109, 110, and a RAKE combining circuit 111, respectively.

15 The delay profile measuring circuits 109 and 110 measure delay profiles of output signals of matched filters 107 and 108, respectively to obtain arrival time of signals of the respective paths and power at each arrival time, and output time 20 information of received paths to the RAKE combining circuit 111, respectively.

The RAKE combining circuit 111 synchronizes time of the respective signals, each having a different arrival time output from the matched 25 filters 107 and 108, based on time information of reception paths output from the delay profile measuring circuits 109 and 110, and combines these signals, and outputs the resultant to a demodulating

circuit 112. The demodulating circuit 112 demodulates the output signal of RAKE combining circuit 111, and outputs the demodulated signal to a separating circuit 113.

5 The separating circuit 113 separates a control signal from the output signal of demodulating circuit 112 to extract reception data, and picks up a change necessary/unnecessary signal, which shows whether or not an operation for changing an antenna 10 is needed, and an antenna selective signal, which shows a transmission antenna number, and outputs the resultant to an antenna change controlling section 114.

The antenna change controlling section 114 15 reads the change necessary/unnecessary signal from the separating circuit 113. Then, in a case where the operation for changing an antenna is necessary, the antenna change controlling section 114 performs the operation for changing an antenna, that is, the 20 change of a selector 118 to transmit the signal from the antenna, which is shown by the antenna selective signal output from the separating circuit 113.

A modulating circuit 115 provides primary modulation such as PSK and secondary modulation, 25 which multiplies control signal A by spreading code A, to control signal A, and outputs the resultant to an adder 119. A modulating circuit 116 provides primary modulation such as PSK and secondary

modulation, which multiplies control signal B by spreading code B, to control signal B, and outputs the resultant to an adder 120. A modulating circuit 115 provides primary modulation such as PSK and 5 secondary modulation, which multiplies transmission data by spreading code A, to transmission data, and outputs the resultant to the selector 118.

The selector 118 outputs the output signal of 10 the modulating circuit 117 to either the adder 119 or the adder 120 by control of the antenna change controlling circuit 114. The adder 119 or 120 multiplexes the input signal, and outputs the multiplexed signal to transmission RF section 121 15 or 122, respectively.

The transmission RF section 121 provides processing such as quadrature modulation, frequency conversion, amplification, and the like to the output signal of adder 119, and performs radio 20 transmission from the antenna 101 through the antenna duplexer 103. Similarly, the transmission RF section 122 provides processing such as quadrature modulation, frequency conversion, amplification, and the like to the output signal of 25 adder 120, and performs radio transmission from the antenna 102 through the antenna duplexer 104.

FIG. 2 is a block diagram showing the configuration of the terminal apparatus according

to Embodiment 1.

In the terminal apparatus of FIG. 2, an antenna duplexer 202 is used such that the same antenna is employed in both transmission and reception. The 5 antenna duplexer 202 outputs a signal radio received by an antenna 201 to a reception RF section 203, and outputs a transmission signal output from a transmission RF section 216 to the antenna 201. The reception RF section 203 amplifies a received signal 10 input from the antenna duplexer 202, frequency converts the amplified signal to intermediate or baseband frequency, and outputs the frequency-converted signal to matched filters 204, 205, and 206.

15 The matched filter 204 performs despreading by multiplying the output signal of reception RF section 203 by spreading code A, and outputs the resultant to a power measuring circuit 210. Similarly, the matched filter 205 performs 20 despreading by multiplying the output signal of reception RF section 203 by spreading code B, and outputs the resultant to a power measuring circuit 211.

The matched filter 206 performs despreading by 25 multiplying the output signal of reception RF section 203 by spreading code C, and outputs the resultant to a delay profile measuring circuit 207 and a RAKE combining circuit 208.

The delay profile measuring circuit 207 measures a delay profile of an output signal of the matched filter 206 to obtain arrival time of the respective paths and power at each arrival time, and 5 outputs time information of reception path to a RAKE combining circuit 208 and a determining circuit 213. In the case of transmitting data in a burst manner, profile measurement is performed with respect to the control signal. In this case, the profile 10 measurement is performed based on the output of the matched filter 204 or 205.

The RAKE combining circuit 208 synchronizes time of the respective signals, each having a different arrival time output from the matched 15 filter 206, based on time information of reception path output from the delay profile measuring circuit 207, and combines these signals. A demodulating circuit 209 demodulates the output signal of RAKE combining circuit 208 to extract received data.

20 A power measuring circuit 210 measures an output power of the matched filter 204, and outputs the measurement result to a comparison circuit 212. Similarly, a power measuring circuit 211 measures an output power of the matched filter 205, and 25 outputs the measurement result to the comparison circuit 212. The comparison circuit 212 compares power measured by the power measuring circuit 210 with power measured by the power measuring circuit

211, generates an antenna selective signal, which shows larger spreading code, that is, an antenna number of the base station apparatus, and outputs the resultant to a multiplexing circuit 214.

5 The determining circuit 213 measures the number of paths from time information of reception path, generates a change necessary/unnecessary signal, which shows whether or not an operation for changing an antenna is needed, that is, reception
10 quality is improved by changing the antenna, and outputs the resultant to the multiplexing circuit 214.

The multiplexing circuit 214 multiplexes the change necessary/unnecessary signal output from the
15 determining circuit 213 and the antenna selective signal output from the comparison circuit 212 into transmission data in a frame format, and outputs the resultant to the modulating circuit 215. The modulating circuit 215 provides primary modulation such as PSK and secondary modulation, which multiplies the output signal of multiplexing circuit 214 by spreading code D, to the output signal of the multiplexing circuit 214, and outputs the resultant to a transmission RF section 216. The
20 transmission RF section 216 provides processing such as quadrature modulation, frequency conversion, amplification, and the like to the output signal of the modulating circuit 215, and
25

performs radio transmission from the antenna 201 through the antenna duplexer 202.

Next, a specific explanation is given of delay profile measurement processing in the delay profile measuring circuits 109, 110 of FIG. 1 and the delay profile measuring circuit 207 of FIG. 2 with reference to a drawing illustrating an example of delay profile of FIG. 3. In FIG. 3, a horizontal axis denotes time and a vertical axis denotes power.

In radio communications, there is a delay wave in which the transmitted signal arrives at the receiving side after being reflected on a mountain, a building, and the like in addition to a direct wave in which the transmitted signal directly arrives at the receiving side. FIG. 3 shows that a direct wave signal of power p_0 arrives at time t_0 , and delay wave signals of p_1 , p_2 , p_3 arrive at time t_1 , t_2 , t_3 , respectively.

The delay profile measuring circuits 109 and 110 and the delay profile measuring circuit 207 measure the delay profile as shown in FIG. 3 so as to obtain the number of paths, in which power is higher than a preset threshold value, and arrival time of each path. In the case of FIG. 3, since power of received signal at time t_0 and time t_1 is higher than the threshold value, the number of paths is set to 2.

Next, an explanation is given of determination

processing of determining circuit 213 of Example 1 with reference to the flowchart of FIG. 4.

First, the determining circuit 213 determines whether or not the number of paths input from the 5 delay profile measuring circuit 207 is smaller than the preset threshold value (ST11). If the number of paths is smaller than the preset threshold value, the determining circuit 213 generates the change necessary/unnecessary signal having information to 10 the effect that the operation for changing an antenna is necessary (ST12). Moreover, if the number of paths is larger or equal than/to the preset threshold value, the determining circuit 213 generates the change necessary/unnecessary signal 15 having information to the effect that the operation for changing antenna is unnecessary (ST13).

For example, in a case where the preset threshold value is "3" and the delay profile shown in FIG. 3 is measured by the delay profile measuring 20 circuit 207, the number of paths to be input to the determining circuit 213 is "2", which is smaller than the threshold value "3." Therefore, the determining circuit 213 generates the change necessary/unnecessary signal having information to 25 the effect that the operation for changing an antenna is necessary, and outputs it to the multiplexing circuit 214.

Next, an explanation will be given of the flow

of the signal of the reverse link in the radio communication system of Embodiment 1.

The multiplexing circuit 214 multiplexes the change necessary/unnecessary signal and the antenna selective signal into transmission data from the terminal apparatus in the frame format, and the modulating circuit 215 provides primary modulation such as PSK and secondary modulation, which multiplies the output signal of multiplexing circuit 214 by spreading code D, to the output signal of the multiplexing circuit 214. The transmission RF section 216 provides processing such as quadrature modulation, frequency conversion, amplification, and the like to the output signal of the modulating circuit 215, and performs radio transmission from the antenna 201 through the antenna duplexer 202.

The signals radio transmitted from the antenna 201 of the terminal apparatus are received by the antennas 101 and 102 of the base station apparatus.

The signal received by the antenna 101 is input to the reception RF circuit 105 through the antenna duplexer 103, and the input signal is amplified and frequency converted to intermediate or baseband frequency by the reception RF circuit 105. The output signal of reception RF circuit 105 is despread by the matched filter 107 using despreading code D, and the despread signal is output to the

delay profile measuring circuit 109 and RAKE combining circuit 111. The delay profile measuring circuit 109 measures the profile of the output signal of matched filter 107 to obtain arrival time 5 of each reception path and power at each arrival time, and outputs time information of reception path to the RAKE combining circuit 111.

Similarly, the signal received by the antenna 102 is input to the reception RF circuit 106 through 10 the antenna duplexer 104, and the input signal is amplified and frequency converted to intermediate or baseband frequency by the reception RF circuit 106. The output signal of reception RF circuit 106 is despread by the matched filter 108 using 15 despread code D, and the despread signal is output to the delay profile measuring circuit 110 and RAKE combining circuit 111. The delay profile measuring circuit 110 measures the profile of the output signal of matched filter 108 to obtain 20 arrival time of each reception path and power at each arrival time, and outputs time information of reception path to the RAKE combining circuit 111.

The RAKE combining circuit 111 combines the respective signals each having a different arrival 25 time, and the demodulating circuit 112 demodulates the combined signals, and the separating circuit 113 separates the change necessary/unnecessary signal and the antenna selective signal so as to extract

received data.

The separated necessary/unnecessary signal and the antenna selective signal are output to the antenna change controlling circuit 114. The antenna
5 change controlling circuit 114 determines whether or not the change of antenna is executed based on the necessary/unnecessary signal. Then, if the change of antenna is executed, the selector 118 is changed based on the antenna selective signal.

10 Next, an explanation will be given of the signal flow of the forward link in the radio communication system of Embodiment 1.

Control signal A transmitted from the base station apparatus is subjected to primary processing such as PSK by the modulating circuit 115. Moreover, secondary modulation processing of spread processing using spreading code A is provided thereto, and the resultant is output to the adder 119. Similarly, control signal B transmitted from the base station apparatus is subjected to primary processing such as PSK by the modulating circuit 116. Moreover, secondary modulation processing of spread processing using spreading code B is provided thereto, and the resultant is output to the adder
20 25 119.

Transmission data of the forward link transmitted from the base station apparatus is subjected to primary processing such as PSK by the

modulating circuit 117. Moreover, secondary modulation processing of spread processing using spreading code C is provided thereto, and the resultant is output to the adder 119 or 120 through 5 the selector 118, and control signals A and B are multiplexed.

The transmission RF section 121 provides processing such as quadrature modulation, frequency conversion, amplification, and the like 10 to the output signal of adder 119, and performs radio transmission from the antenna 101 through the antenna duplexer 103. The transmission RF section 122 provides processing such as quadrature modulation, frequency conversion, amplification, 15 and the like to the output signal of adder 120, and performs radio transmission from the antenna 102 through the antenna duplexer 104.

The signals radio transmitted from the antennas 101 and 102 of the base station apparatus 20 are received by the antenna 201 of the terminal apparatus.

The signal received by the antenna 201 is input to the reception RF circuit 203 via the antenna duplexer 202. The input signal is amplified, and 25 frequency converted to intermediate frequency or baseband frequency, and the frequency converted signal is input to the matched filters 204, 205, and 206.

The matched filter 206 provides despread processing to the signal input thereto using spreading code C, and outputs the resultant to the delay profile measuring circuit 207 and RAKE 5 combining circuit 208.

The delay profile measuring circuit 207 measures the delay profile of the output signal of matched filter 206 to obtain arrival time of each reception path and power at each arrival time, and 10 outputs time information of the reception path to the RAKE combining circuit 208 and determining circuit 213.

The RAKE combining circuit 208 combines the respective signals each having a different arrival 15 time, and the demodulating circuit 209 demodulates the combined signals to extract received data.

The determining circuit 213 measures the number of paths from time information of the reception path and generates the change 20 necessary/unnecessary signal based on the measured number of paths, and outputs the resultant to the multiplexing circuit 214.

The matched filter 204 provides despread processing to the signal input thereto using 25 spreading code A. Then, the power measuring circuit 210 measures power, and the result of measurement is output to the comparison circuit 212. Similarly, the matched filter 205 provides despread processing

to the signal input thereto using spreading code B. Then, the power measuring circuit 211 measures power, and the result of measurement is output to the comparison circuit 212. The comparison circuit 212
5 compares power measured by the power measuring circuit 210 with power measured by the power measuring circuit 211, generates the antenna selective signal, which shows larger spreading code, that is, the antenna number of the base station
10 apparatus, and outputs the resultant to the multiplexing circuit 214.

Thus, in the case where the number of paths is small, the propagation path is selected to execute the change of antenna, and this makes it possible
15 to improve reception quality. While, in the case where the number of paths is large, path diversity effect, which is caused by RAKE combining, can be obtained. As a result, control is performed to prevent the antenna from being changed, and this
20 makes it possible to prevent a sudden change in interference power to the other terminal apparatus from being caused by the change of antenna, and to suppress deterioration in reception quality of the other terminal apparatus.

25 (Embodiment 2)

Embodiment 2 is a specific form wherein the terminal apparatus measures the number of reception paths from the received signal, transmits

information, which shows the number of paths, to a base station, and the base station determines whether or not the change of antenna is needed based on the number of paths received from the terminal apparatus, and selects whether or not the change of antenna is executed based on the determination result.

FIG. 5 is a block diagram showing the configuration of the base station apparatus according to Embodiment 2 of the present invention. The base station apparatus of FIG. 5 adopts the configuration in which a determining circuit 301 is added to the base station apparatus of FIG. 1. In the base station apparatus of FIG. 5, the same reference numerals as those of FIG. 1 are added to the configuration portions, which are common to the base station apparatus of FIG. 1 in connection with the operation, and the explanation is omitted.

The separating circuit 113 separates the control signal from the output signal of demodulating circuit 112 to extract received data, picks up time information of reception path and the antenna selective signal from the control signal, outputs time information of reception path to the determining circuit 301, and outputs the antenna selective signal to the antenna change controlling circuit 114.

The determining circuit 301 measures the

number of paths from time information of reception path output from the separating circuit 113, generates the necessary/unnecessary signal based on the number of paths, and outputs the resultant to 5 the antenna change controlling circuit 114.

The antenna change controlling circuit 114 reads the change necessary/unnecessary signal output from the determining circuit 301. Then, in a case where the operation for changing the antenna 10 is necessary, the antenna change controlling section 114 performs the change of a selector 118 to transmit the signal from the antenna, which is shown by the antenna selective signal output from the separating circuit 113.

FIG. 6 is a block diagram showing the configuration of the terminal apparatus according to Embodiment 2 of the present invention. The terminal apparatus of FIG. 6 adopts the configuration in which the determining circuit 213 is deleted from the terminal apparatus of FIG. 2. In the base station apparatus of FIG. 6, the same reference numerals as those of FIG. 2 are added to the configuration portions, which are common to the base station apparatus of FIG. 2 in connection with 20 the operation, and the explanation is omitted.

The delay profile measuring circuit 207 measures the delay profile of the output signal of matched filter 206 so as to obtain arrival time of

each path and power at each arrival time. Then, the delay profile measuring circuit 207 outputs time information of reception path to the RAKE combining circuit 208 and multiplexing circuit 214.

5 The multiplexing circuit 214 multiplexes time information of reception path, which has been output from the delay profile measuring circuit 207, and the antenna selective signal, which has been output from the comparison circuit 212, into transmission data in the frame format, and outputs the resultant to the demodulating circuit 215.

10 Thus, the base station apparatus determines whether or not the change of antenna is executed based on the number of reception paths measured by 15 the terminal apparatus. This makes it possible to reduce the scale of hardware of the terminal apparatus or that of software, and to improve miniaturization of the terminal apparatus and a decrease in power consumption.

20 (Embodiment 3)

Embodiment 3 focuses on the point that the delay profile of the terminal apparatus and that of the base station apparatus are substantially the same as each other. More specifically, Embodiment 3 is 25 a specific form wherein the base station apparatus measures the number of reception paths from the received signal, determines whether or not the change of antenna is needed based on the measured

number of paths, and selects whether or not the change of antenna is executed based on the determination result.

FIG. 7 is a block diagram showing the configuration of the base station apparatus according to Embodiment 3 of the present invention. The base station apparatus of FIG. 7 adopts the configuration in which the determining circuit 401 is added to the base station apparatus of FIG. 1.

10 In the base station apparatus of FIG. 7, the same reference numerals as those of FIG. 1 are added to the configuration portions, which are common to the base station apparatus of FIG. 1 in connection with the operation, and the explanation is omitted.

15 The delay profile measuring circuits 109 and 110 measure the delay profiles of the output signals of matched filters 107 and 108, respectively, so as to obtain the arrival time of the signal of each path and power at each arrival time, and output time information of reception path to RAKE combining circuit 111 and determining circuit 401, respectively.

The determining circuit 401 measures the number of paths from time information of reception path, which has been output from the delay profile measuring circuits 109 and 110, generates the change necessary/unnecessary signal based on the measured number of paths, and outputs the resultant to the

antenna change controlling circuit 114.

The antenna change controlling circuit 114 reads the necessary/unnecessary signal output from the determining circuit 401. Then, if the operation 5 for changing the antenna is needed, the antenna change controlling circuit 114 performs the change of selector 118 to transmit the signal from the antenna, which is shown by the antenna selective signal output from the separating circuit 113.

FIG. 8 is a block diagram showing the configuration of the terminal apparatus according to Embodiment 3 of the present invention. The terminal apparatus of FIG. 8 adopts the configuration in which the determining circuit 213 is deleted from the terminal apparatus of FIG. 2. In the base station apparatus of FIG. 8, the same reference numerals as those of FIG. 2 are added to the configuration portions, which are common to the base station apparatus of FIG. 2 in connection with 15 the operation, and the explanation is omitted. 20

The delay profile measuring circuit 207 measures the delay profile of the output signal of matched filter 206 so as to obtain arrival time of each path and power at each arrival time, and outputs 25 time information of reception path to the RAKE combining circuit 208.

The multiplexing circuit 214 multiplexes the antenna selective signal, which has been output from

the comparison circuit 212, into transmission data in the frame format, and outputs the resultant to the modulating circuit 215.

Thus, attention is paid on the point that the
5 delay profile of the terminal apparatus and that of
the base station apparatus are substantially the
same as each other. Then, the base station apparatus
measures the number of reception paths and
determines whether or not the change of antenna is
10 executed. This makes it possible to reduce the scale
of hardware of the terminal apparatus or that of
software, and to improve miniaturization of the
terminal apparatus and a decrease in power
consumption.

15 (Embodiment 4)

Embodiment 4 focuses on the point that effect
of transmission diversity is small since the length
of time at which the received signal continuously
drops is short when the Doppler frequency is high.
20 More specifically, Embodiment 4 is a specific form
wherein the terminal apparatus measures the number
of reception paths and the Doppler frequency from
the received signal and transmits information,
which shows the number of paths and the Doppler
25 frequency, to the base station apparatus, and the
base station apparatus determines whether or not the
change of antenna is needed based on the number of
paths and the Doppler frequency received from the

terminal apparatus, and selects whether or not the change of antenna is executed based on the determination result.

FIG. 9 is a block diagram showing the configuration of the terminal apparatus according to Embodiment 4 of the present invention. The terminal apparatus of FIG. 9 adopts the configuration in which a Doppler frequency measuring circuit 501 is added to the terminal apparatus of Fig. 2. In the base station apparatus of FIG. 9, the same reference numerals as those of FIG. 2 are added to the configuration portions, which are common to the base station apparatus of FIG. 2 in connection with the operation, and the explanation is omitted.

The matched filter 206 performs despreading by multiplying the output signal of reception RF section 203 by spreading code C, and outputs the resultant to the delay profile measuring circuit 207, RAKE combining circuit 208, and Doppler frequency measuring circuit 501.

The Doppler frequency measuring circuit 501 measures the Doppler frequency of the output signal of matched filter 206, and outputs the result of measurement to the determining circuit 213. It should be noted that the measuring method of Doppler frequency is already proposed in the Document "Basics of Mobile Communications" (Issued on

October 1, 1986, the Institute of Electronics, Information and Communication Engineers) and the like.

The determining circuit 213 measures the 5 number of paths from time information of reception path, which has been output from the delay profile measuring circuit 207, generates the change necessary/unnecessary signal based on the number of paths and the Doppler frequency measured by the 10 Doppler frequency measuring circuit 501, and outputs the resultant to the multiplexing circuit 214.

The following will give an explanation of the determination processing of determining circuit 213 15 of Embodiment 1 with reference to the flowchart of FIG. 10.

First, the determining circuit 213 determines whether or not the number of paths input from the delay profile measuring circuit 207 is smaller than 20 the preset threshold value 1 (ST21). If the number of paths is smaller than the threshold value 1, the determining circuit 213 determines whether or not the Doppler frequency input from the Doppler frequency measuring circuit 501 is smaller than the 25 preset threshold value 2 (ST22). If the Doppler frequency is smaller than the preset threshold value 2, the determining circuit 213 generates the change necessary/unnecessary signal to the effect that the

operation for changing the antenna is necessary (ST23).

If the number of paths is larger or equal than/to the threshold value 1 and the Doppler frequency is larger or equal than/to the preset threshold value 2, the determining circuit 213 generates the change necessary/unnecessary signal to the effect that the operation for changing the antenna is unnecessary (ST24).

Thus, in the case where the number of paths is small and frequency offset is small, the propagation path is selected to execute the change of antenna, and this makes it possible to improve reception quality. While, in the case where the number of paths is large or frequency offset is large, path diversity effect, which is caused by RAKE combining, can be obtained. As a result, control is performed to prevent the antenna from being changed, and this makes it possible to prevent a sudden change in interference power to the other terminal apparatus from being caused by the change of antenna, and to suppress deterioration in reception quality of the other terminal apparatus.

The configuration and operation of the base station apparatus of Embodiment 4 are the same as those of FIG. 1, and the explanation is omitted.

Moreover, Embodiment 4 can be combined with Embodiment 2 or Embodiment 3. Namely, the following

combinations can be executed. Specifically, the terminal apparatus measures the number of paths and the Doppler frequency, and the base station apparatus determines whether or not the change of antenna is needed. The base station apparatus measures the number of paths and the Doppler frequency, and determines whether or not the change of antenna is needed. The terminal apparatus measures the number of paths, and the base station apparatus measures the Doppler frequency and determines whether or not the change of antenna is needed. The terminal apparatus measures the Doppler frequency, and the base station apparatus measures the number of paths and determines whether or not the change of antenna is needed.

As explained above, according to the radio communication apparatus and the radio communication method of the present invention, the change of antenna can be performed at the time, serving as a starting point, when reception quality becomes worse. Moreover, in a case where effect of improving reception performance, which is caused by the change of antenna, is small, the operation for changing the antenna is stopped so that the change in an amount of interference to the other terminal apparatus can be eliminated.

This application is based on the Japanese Patent Application No. HEI 10-328293 filed on

November 18, 1998, entire content of which is
expressly incorporated by reference herein.

CLAIMS

1. A radio communication apparatus comprising:
first path measuring means for measuring the
number of paths of a forward link;

5 first determining means for determining
whether or not an operation for changing an antenna
is needed based on the number of paths; and
 first multiplexing means for multiplexing a
first control signal, which puts a determination
10 result of said first determining means thereon, into
transmission data.

2. The radio communication apparatus according
to claim 1, wherein said first determining means
determines that execution of the operation for
15 changing the antenna is needed when the number of
paths of the forward link is smaller than a first
threshold value.

3. The radio communication apparatus according
to claim 1, further comprising first Doppler
20 frequency measuring means for measuring a Doppler
frequency of a received signal, wherein said first
determining means determines whether or not the
operation for changing the antenna is needed based
on the number of paths of the forward link and
25 Doppler frequency.

4. The radio communication apparatus according
to claim 3, wherein said first determining means
determines that execution of the operation for

changing the antenna is needed when the number of paths of the forward link is smaller than the first threshold value and the Doppler frequency is smaller than a second threshold value, which is present.

5 5. A radio communication apparatus comprising:
 first path number measuring means for
measuring the number of paths of a forward link; and
 second multiplexing means for multiplexing a
second control signal, which puts information
10 showing the number of paths of the forward link
thereon, into transmission data.

6. The radio communication apparatus according
to claim 5, further comprising first Doppler
frequency measuring means for measuring Doppler
15 frequency of a received signal, wherein said second
multiplexing means multiplexes said second control
signal, which puts information showing the number
of paths of the forward link thereon, a third control
signal, which puts information showing the Doppler
20 frequency thereon, into transmission data.

7. A communication terminal apparatus, having
a radio communication apparatus thereon, said radio
communication apparatus comprising:

 first path measuring means for measuring the
25 number of paths of a forward link;

 first determining means for determining
whether or not an operation for changing an antenna
is needed based on the number of paths; and

first multiplexing means for multiplexing a first control signal, which puts a determination result of said first determining means thereon, into transmission data.

5 8. A radio communication apparatus comprising:

 first separating means for separating a first control signal from a received signal; and

 first change controlling means for determining whether or not an operation for changing a 10 transmission antenna is executed based on said first control signal.

9. A radio communication apparatus comprising:

 second separating means for separating a second control signal from a received signal;

 second determining means for determining whether or not an operation for changing an antenna is executed based on said second control signal; and

 second change controlling means for determining whether or not an operation for changing 20 a transmission antenna is executed based on determination result of said second determining means.

10. The radio communication apparatus according to claim 9, wherein said second

25 determining means determines that execution of the operation for changing the antenna is needed when the number of paths of a forward link is smaller than a first threshold value, which is preset.

11. The radio communication apparatus according to claim 9, wherein said second separating means separates a second control signal and a third control signal from a received signal, and said 5 second determining means determines whether or not the operation for changing an antenna is needed based on said second control signal and third control signal.

12. The radio communication apparatus 10 according to claim 11, wherein said second determining means determines that execution of the operation for changing the antenna is needed when the number of paths of a forward link is smaller than the first threshold value, which is preset, and 15 Doppler frequency is smaller than a second threshold value, which is preset.

13. A radio communication apparatus comprising:

second path number measuring means for 20 measuring the number of paths of a reverse link; third determining means for determining whether or not a change of antenna is needed based on the number of paths of the reverse link; and third change controlling means for determining 25 whether or not an operation for changing a transmission antenna is executed based on a determination result of said third determining means.

14. The radio communication apparatus according to claim 13, wherein said third determining means determines that execution of the operation for changing the antenna is needed when 5 the number of paths of the reverse link is smaller than a third threshold value, which is preset.

15. The radio communication apparatus according to claim 13, further comprising second Doppler frequency measuring means for measuring a 10 Doppler frequency of a received signal, wherein said third determining means determines whether or not the change of antenna is needed based on the number of paths of the reverse link and the Doppler frequency.

15 16. The radio communication apparatus according to claim 13, wherein said third determining means determines that the change of antenna is needed when the number of paths of the reverse link is smaller than the third threshold 20 value, which is preset, and the Doppler frequency is smaller than a fourth threshold value, which is preset.

17. A base station apparatus, having a radio communication apparatus thereon, said radio 25 communication apparatus comprising:

first separating means for separating a first control signal from a received signal; and

first change controlling means for determining

whether or not an operation for changing a transmission antenna is executed based on said first control signal.

18. A transmission antenna changing method
5 comprising the steps of:

measuring the number of paths of a link;
determining whether or not an operation for changing an antenna is needed based on the measured number of paths; and

10 performing change-control to determine whether or not an operation for changing a transmission antenna of forward transmission data is executed based on a determination result of said determining step.

15 19. The transmission antenna changing method according to claim 18, wherein it is determined in said determining step that execution of the operation for changing the antenna is needed when the number of paths of the link is smaller than a 20 first threshold value, which is preset.

20. The transmission antenna changing method according to claim 18, further comprising a step of measuring a Doppler frequency of a received signal, wherein said determining step determines whether or 25 not the operation for changing the antenna is needed based on the number of paths of the link and the Doppler frequency.

21. The transmission antenna changing method

according to claim 20, wherein it is determined in said determining step that execution of the operation for changing the antenna is needed when the number of paths of the link is smaller than the 5 first threshold value, which is preset, and the Doppler frequency is smaller than a second threshold value, which is present.

ABSTRACT

A determining circuit 213 of a mobile station measures the number of paths of a forward link. In 5 a case where the number of paths is smaller than a threshold value, the determining circuit 213 determines that execution of an operation for changing an antenna is necessary. In the other case, the determining circuit 213 determines that 10 execution of an operation for changing an antenna is unnecessary. A multiplexing circuit 214 multiplexes a control signal, which puts the determination result of determining circuit 213 thereon, into transmission data to be transmitted. 15 In a base station apparatus, the control signal is separated from the received signal, and it is determined whether or not the operation for changing the antenna is executed. This makes it possible to execute the operation for changing transmission 20 antenna only when reception quality is improved by changing transmission antenna, and to suppress execution of the change of transmission antenna to a minimum.

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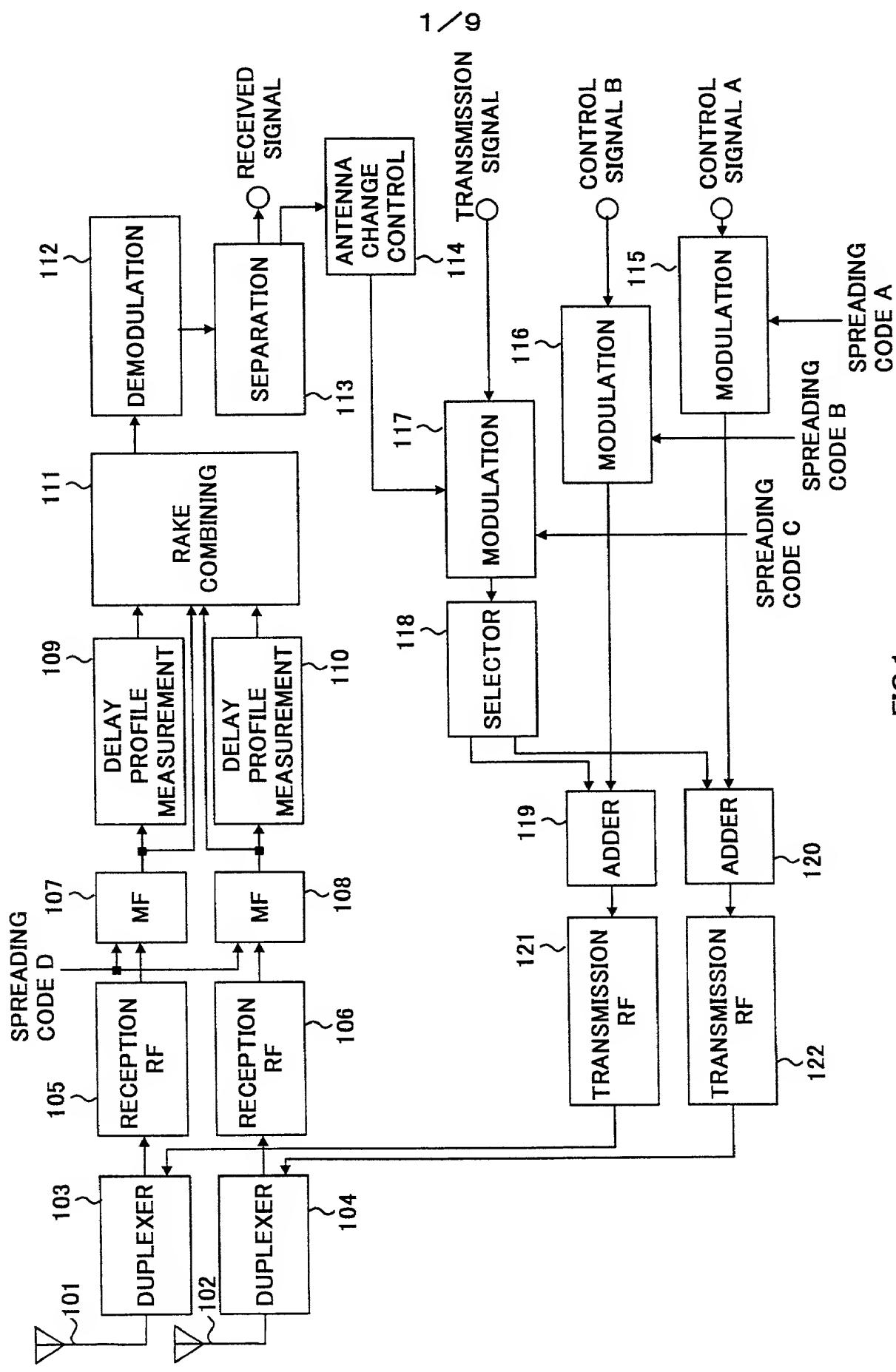


FIG.1

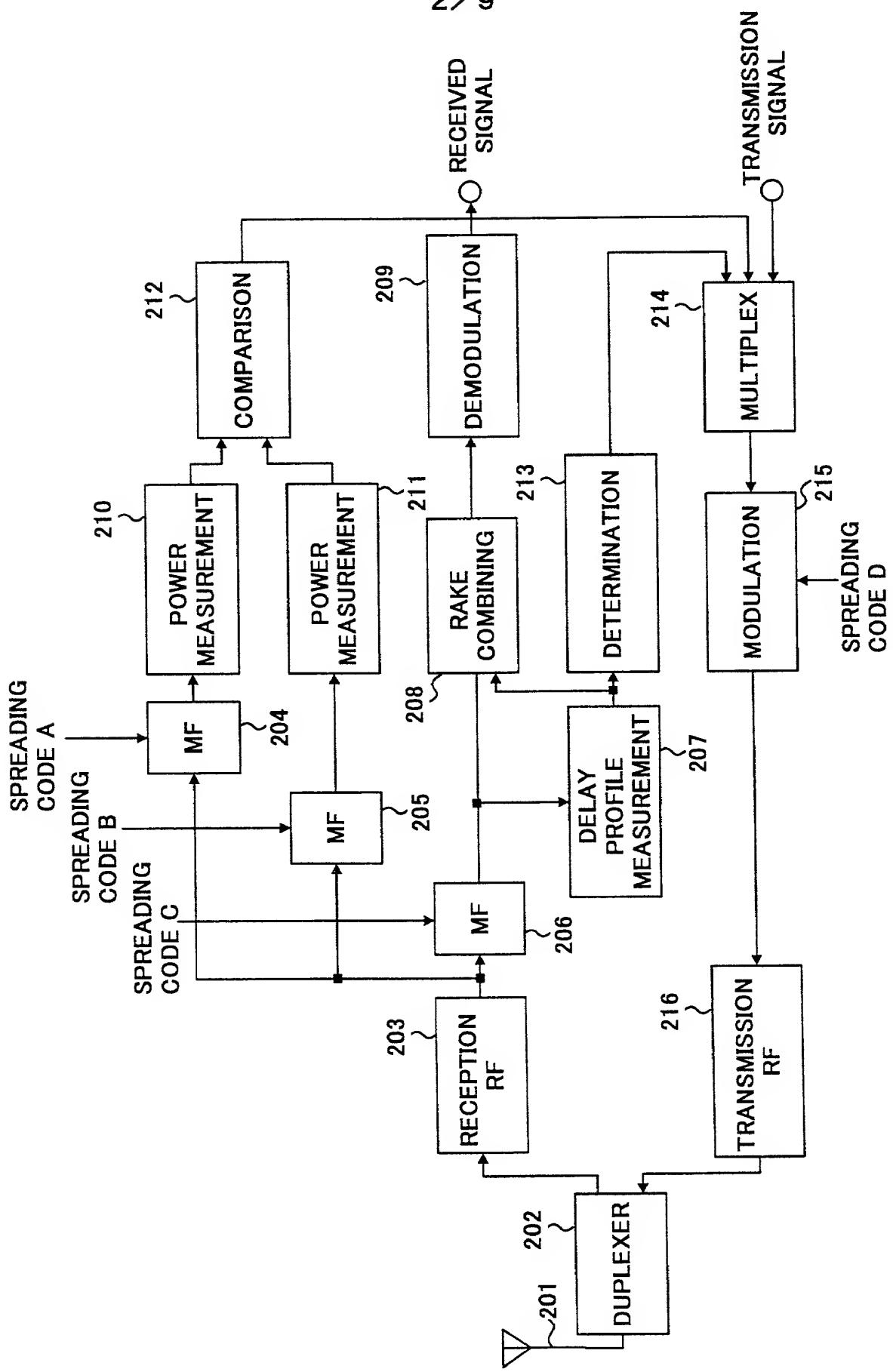


FIG.2

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FIG.3

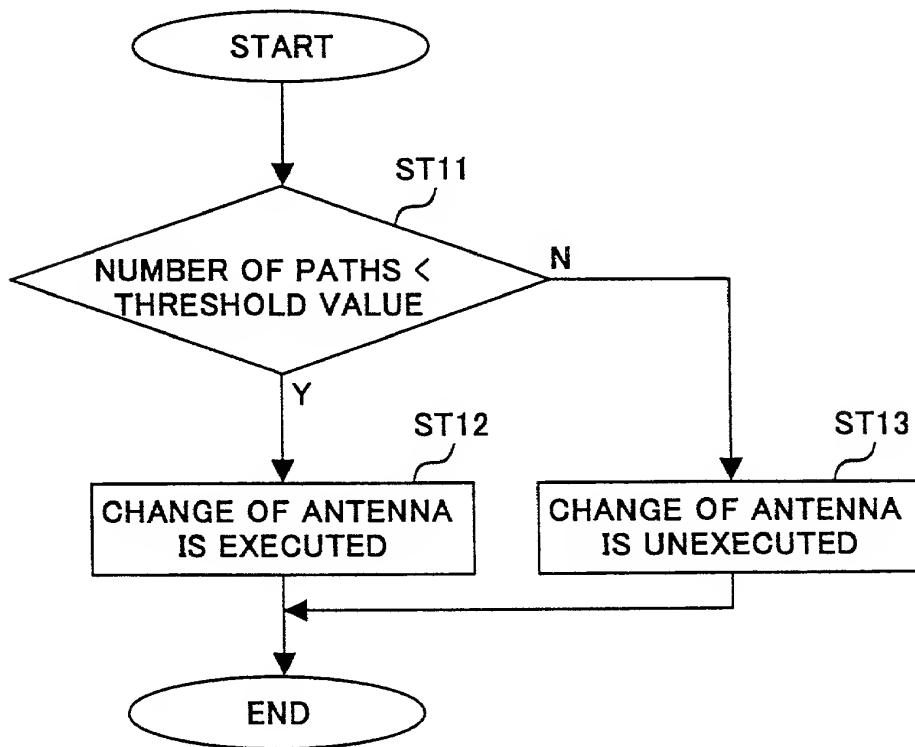


FIG.4

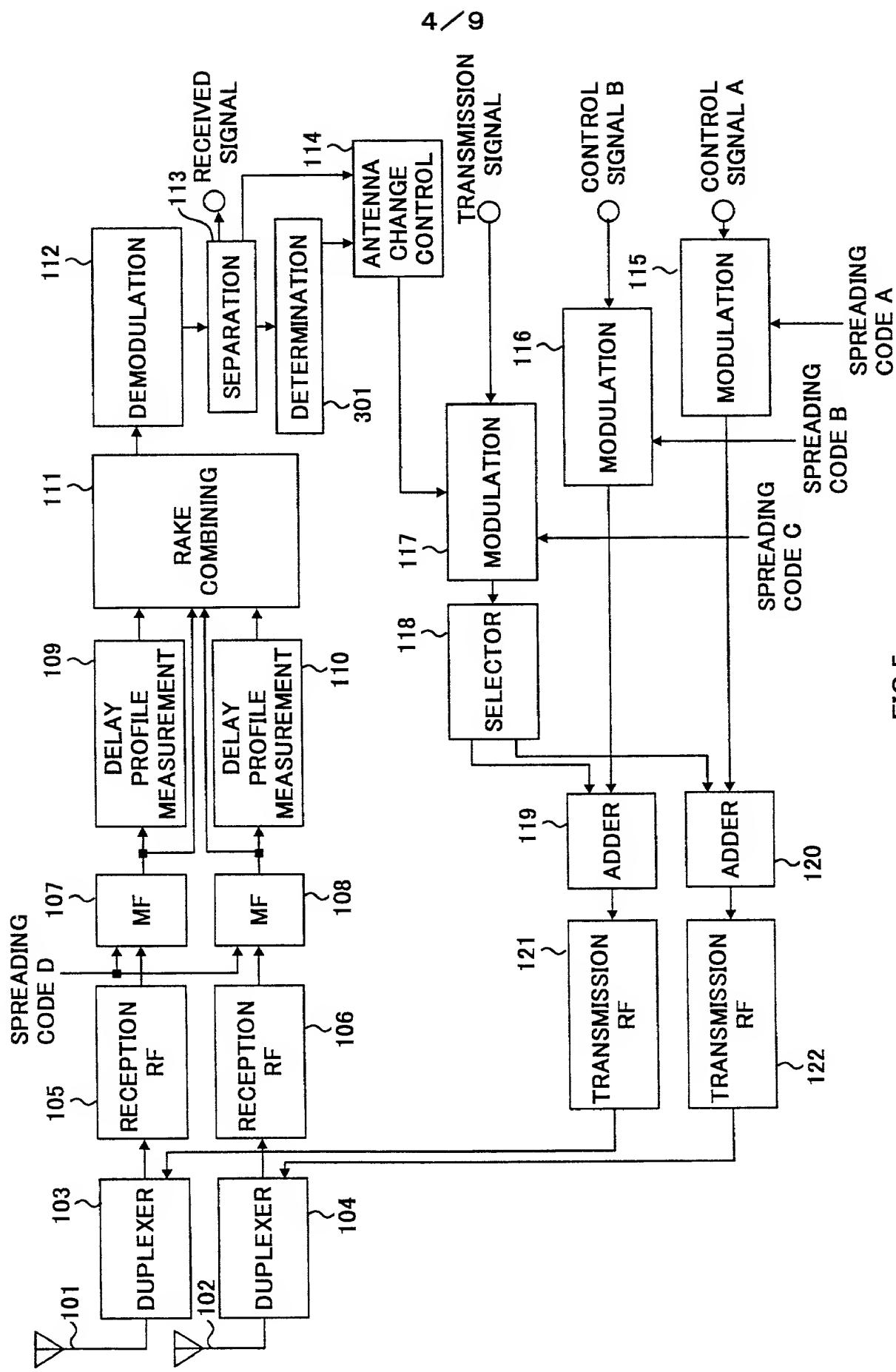


FIG.5

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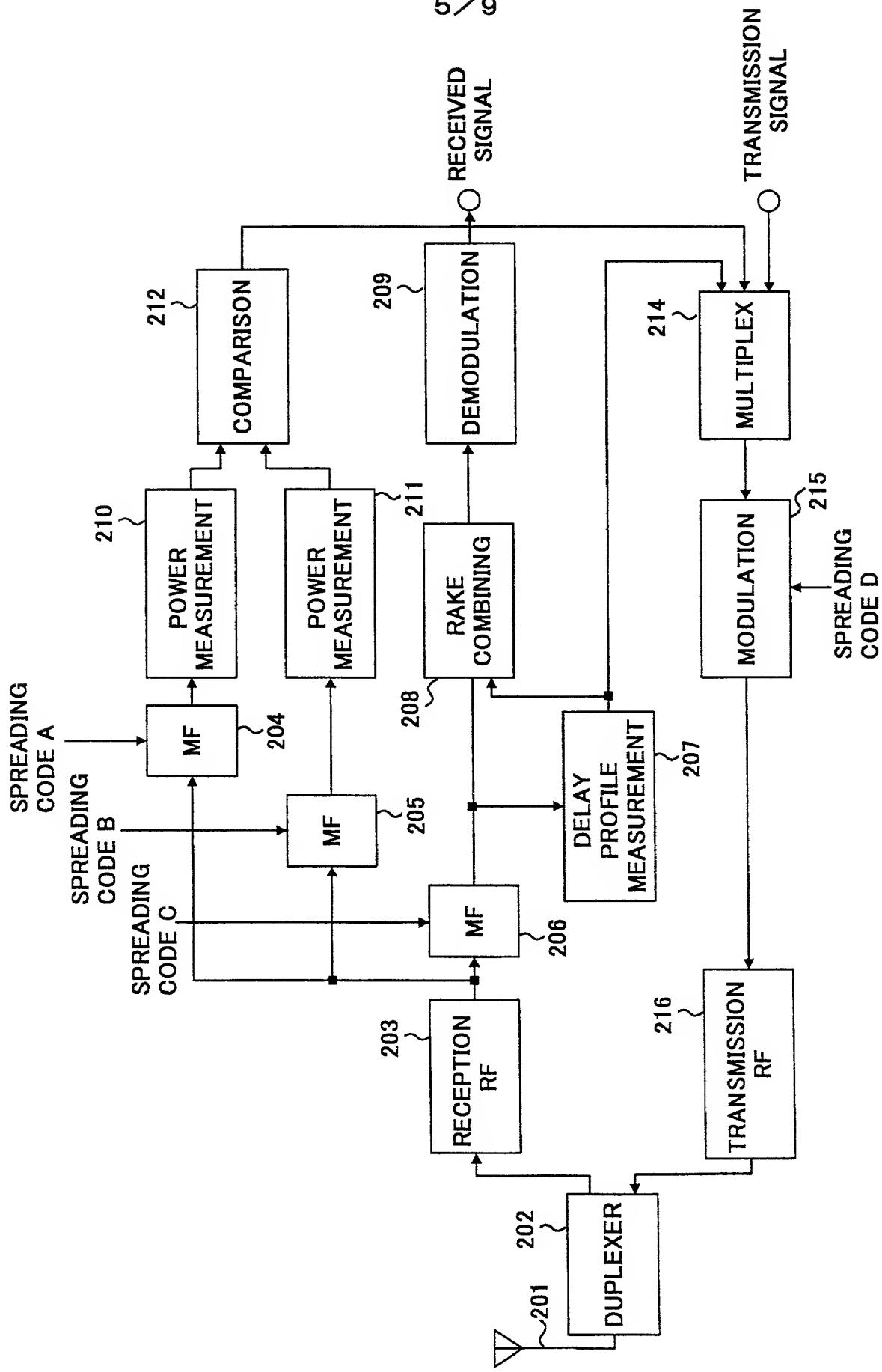


FIG.6

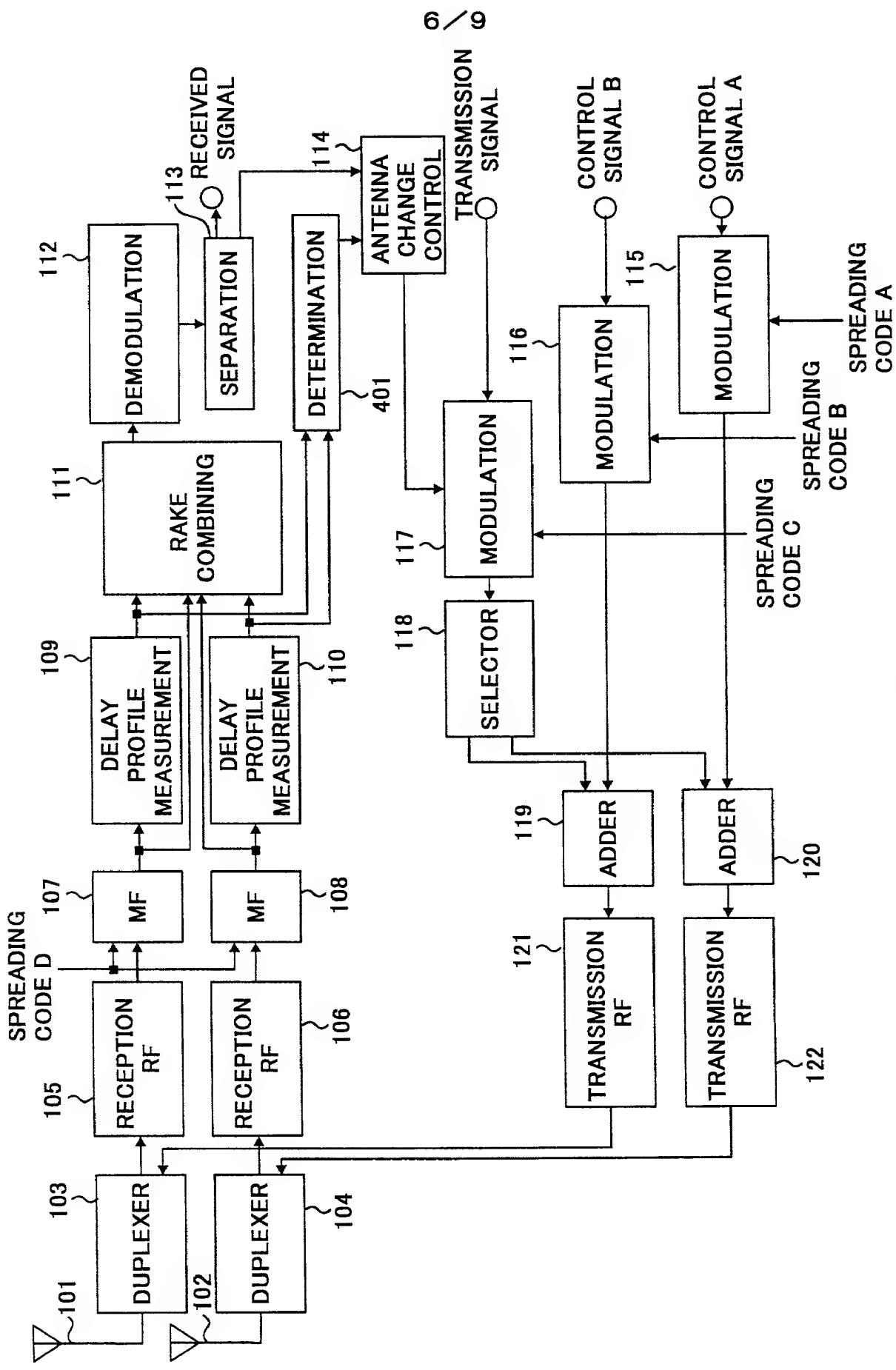


FIG.7

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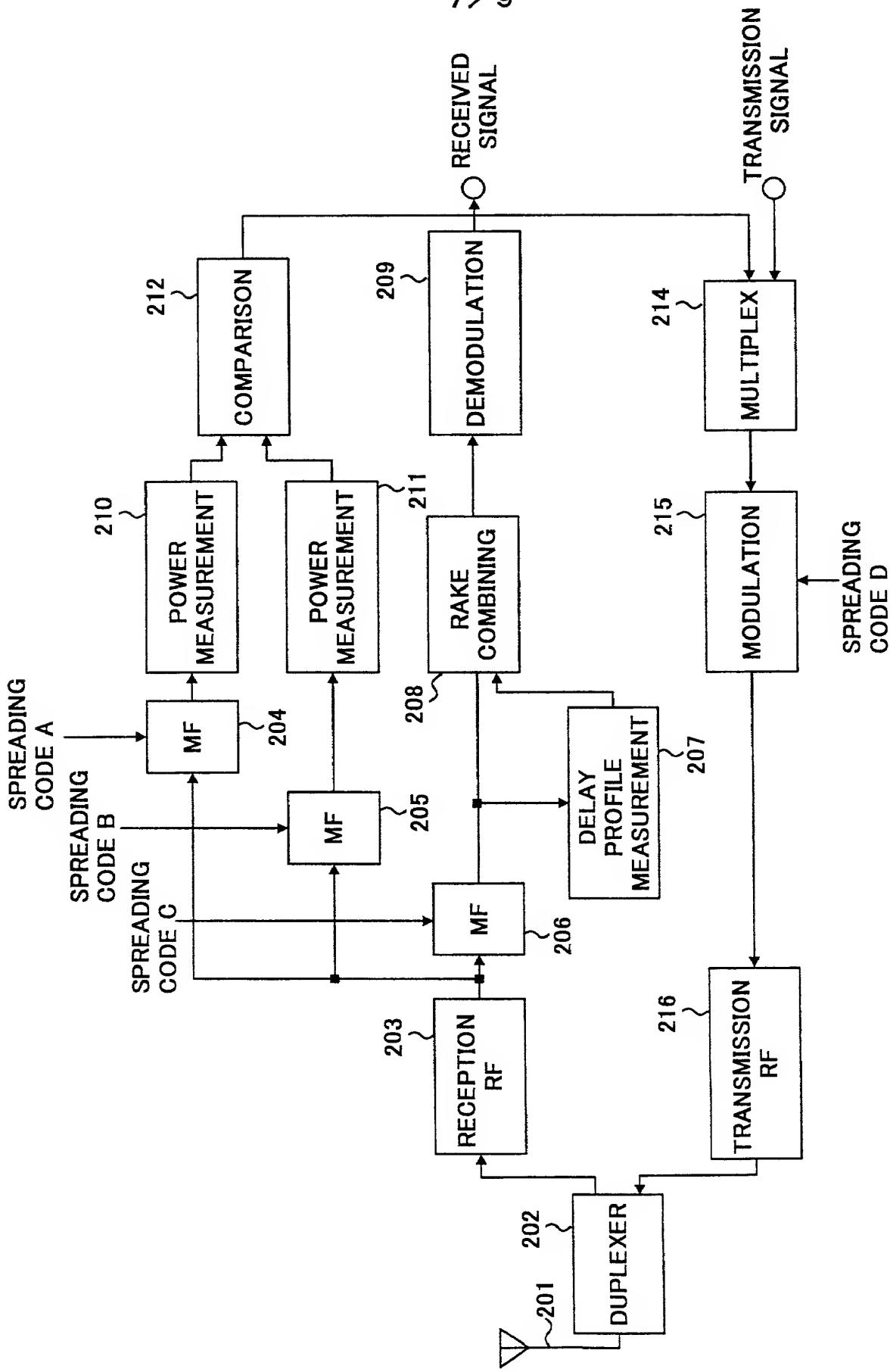


FIG. 8

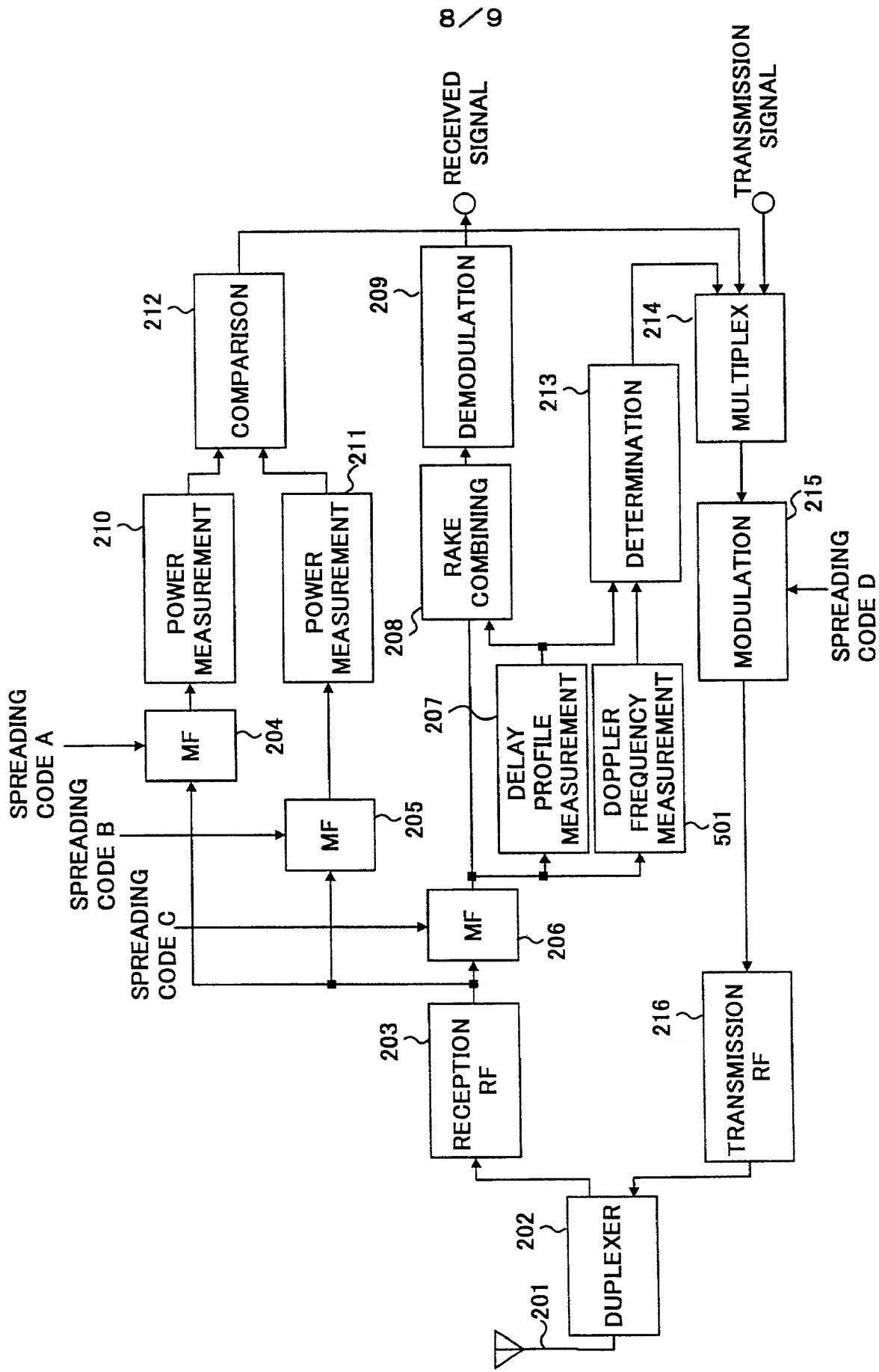


FIG.9

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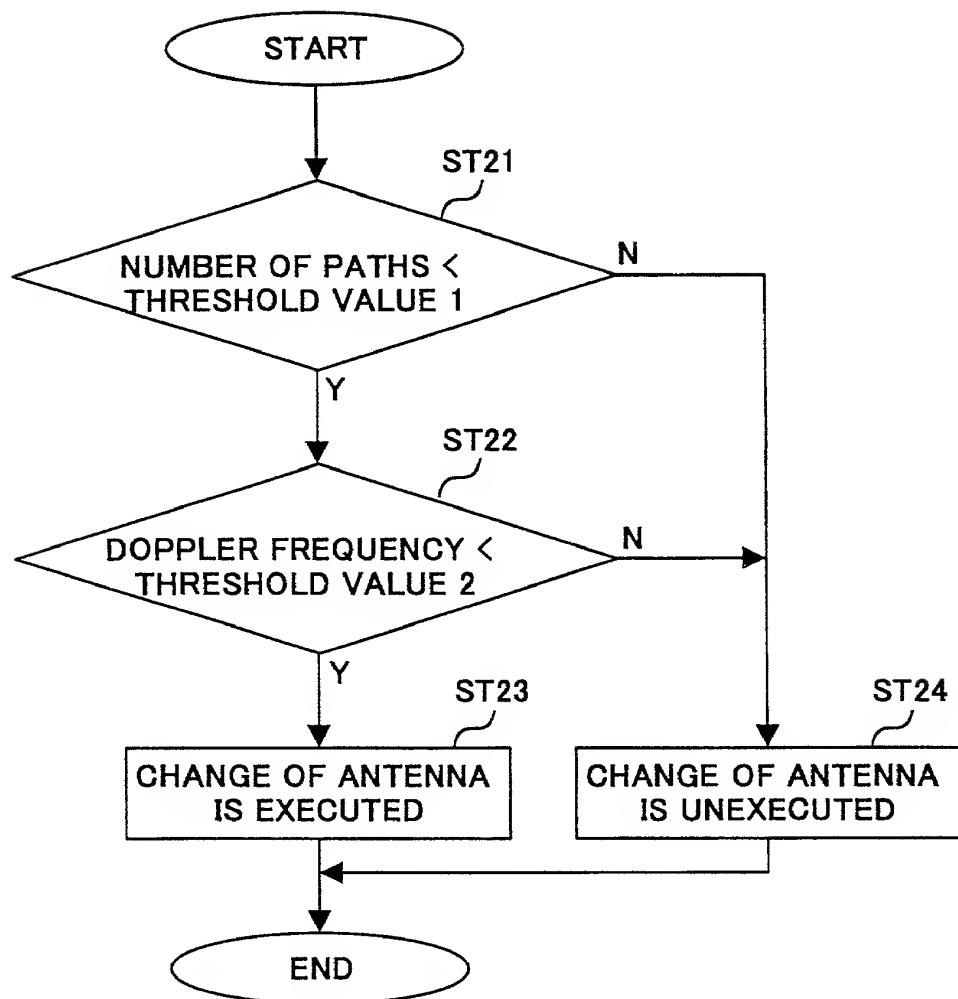


FIG.10

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: **RADIO COMMUNICATION APPARATUS AND TRANSMISSION ANTENNA CHANGING METHOD**

the specification of which 2 (file no. _____)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.

7 [x] was filed as PCT international application

8 Number PCT/JP99/06378

9 on November 16, 1999

and was amended under PCT Article(s) 19 and/or 34

10 on _____ (if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

| | | | | |
|--|--------------------------------|---|---|---------------------------------|
| Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119 | | | Priority Claimed | |
| JAPAN (Country) | JP10-328293 (Number) | 18/November/1998 (Day/Month/Year Filed) | <input checked="" type="checkbox"/> Yes | <input type="checkbox"/> No |
| (Country) | (Number) | (Day/Month/Year Filed) | <input type="checkbox"/> Yes | <input type="checkbox"/> No |

[] Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

[] Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

| | | | |
|---|--|---------------------------|----------------------|
| 11b Application No. | Day/Month/Year Filed | Application No. | Day/Month/Year Filed |
| <p>Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application</p> | <p>I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.</p> | | |
| | 13 _____ | (U.S. Application Number) | (U.S. Filing Date) |

[Signature] I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO
STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036,
TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.

See page 2 for signature lines

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

| | | | | | |
|-----|--|--|-------------------|-----------------|--------------|
| 13a | Typewritten Full Name of Sole or First Inventor |  Katsuhiko | Given Name | Middle Name | Family Name |
| 14a | Inventor's Signature | <u>Katsuhiko</u> | | | |
| 15a | Date of Signature | <u>June</u> | <u>2</u> | <u>2000</u> | |
| 16a | Residence | <u>Yokosuka-shi</u> | <u>Japan</u> | <u>Kanagawa</u> | <u>JAPAN</u> |
| 17a | Citizenship | <u>JAPAN</u> | | | |
| 18a | Post Office Address <i>(Insert complete mailing address, including country)</i> | <u>4-21-4-102, Kurihama,</u> <u>Yokosuka-shi, Kanagawa 239-0831 JAPAN</u> | | | |
| 13b | Typewritten Full Name of Sole or First Inventor | Given Name | Middle Name | Family Name | |
| 14b | Inventor's Signature | | | | |
| 15b | Date of Signature | Month | Day | Year | |
| 16b | Residence | City | State or Province | Country | |
| 17b | Citizenship | | | | |
| 18b | Post Office Address <i>(Insert complete mailing address, including country)</i> | | | | |
| 13c | Typewritten Full Name of Sole or First Inventor | Given Name | Middle Name | Family Name | |
| 14c | Inventor's Signature | | | | |
| 15c | Date of Signature | Month | Day | Year | |
| 16c | Residence | City | State or Province | Country | |
| 17c | Citizenship | | | | |
| 18c | Post Office Address <i>(Insert complete mailing address, including country)</i> | | | | |
| 13d | Typewritten Full Name of Sole or First Inventor | Given Name | Middle Name | Family Name | |
| 14d | Inventor's Signature | | | | |
| 15d | Date of Signature | Month | Day | Year | |
| 16d | Residence | City | State or Province | Country | |
| 17d | Citizenship | | | | |
| 18d | Post Office Address <i>(Insert complete mailing address, including country)</i> | | | | |

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.